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JC962 U.S. PTO 03/14/02

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/088551

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE(S) CLAIMED
PCT/DE00/02730	(12.08.00) 12 August 2000	(15.09.99) 15 September1999

TITLE OF INVENTION
SHEATHED-ELEMENT GLOW PLUG

APPLICANT(S) FOR DO/EO/US
BAUER, Hans-Peter; GEISSINGER, Albrecht; LOCHER, Johannes; TESCHNER, Werner; and NEUMEISTER, Joachen

Applicant(s) herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1)
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2))
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau)
   b. ☐ have been transmitted by the International Bureau
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U S.C. 371(c)(3))
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment
    ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment
14. ☒ A substitute specification and a marked up version thereof.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), Preliminary Examination Report (translated) and Form PCT/RO/101.

Express Mail No. EL594613122

U.S. APPLICATION NO. if known, see 37 C.F.R.1.5	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/088551	PCT/DE00/02730	10191/2327

17. ☒ The following fees are submitted	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $890 00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) . . $710 00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $740 00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1 445(a)(2)) paid to USPTO $1,040.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	9 - 20 =	0	X $18.00	$ 0	
Independent Claims	1 - 3 =	0	X $84 00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$ 0	
TOTAL OF ABOVE CALCULATIONS =				$ 890	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1 9, 1.27, 1.28).				$	
SUBTOTAL =				$ 890	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 890	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40 00 per property +				$	
TOTAL FEES ENCLOSED =				$ 890	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of $890.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1 137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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for Richard Mayer (by G. Lee B. No. 36,197)
SIGNATURE

Richard L. Mayer, Reg. No 22,490
NAME

3/14/02
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Hans-Peter BAUER et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	SHEATHED-ELEMENT GLOW PLUG
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to:
--What Is Claimed Is:--.

Please cancel claims 1-9, without prejudice, in the underlying PCT application. Please also cancel, without prejudice, substitute claims 1-9 presented in the annex to the International Preliminary Examination Report.

Please add the following new claims:

--10. (New) A sheathed-element glow plug for a self-igniting internal combustion engine, comprising:

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a heating element projecting into a combustion chamber of the internal combustion engine;

a current feed-through via which a heating current for the heating element is fed through an opening in the combustion chamber; and

a switch positioned in the region of the current feed-through, wherein the heating current is adapted to be controlled by opening and closing the switch.

11. (New) The sheathed-element glow plug as recited in Claim 10, wherein a control circuit for the switch is positioned in the region of the current feed-through, and wherein the control circuit produces a signal for opening and closing the switch.

12. (New) The sheathed-element glow plug as recited in Claim 11, further comprising a first feed line adapted to be connected to a terminal for a supply voltage for the heating current, and a second feed line connected to the control circuit for transmitting a control signal to the control circuit.

13. (New) The control circuit as recited in Claim 11, further comprising an input for a line, wherein the input is connected to the switch and the control circuit, and wherein an operating voltage and a control signal for the control circuit are adapted to be simultaneously applied via the input.

14. (New) The sheathed-element glow plug as recited in Claim 11, wherein the control circuit includes a means for determining the temperature of the heating element, and wherein the heating current is controlled as a function of a signal from said means.

15. (New) The sheathed-element glow plug as recited in Claim 10, wherein the heating element is one of a metallic and ceramic glow element.

16. (New) The sheathed-element glow plug as recited in Claim 15, wherein the glow element is adapted to be fastened in the opening of the combustion chamber by use of a housing, and wherein the housing is also adapted to house the switch and the control unit.

17. (New) The sheathed-element glow plug as recited in Claim 16, wherein the switch and the control circuit are integrated on one chip.

18. (New) The sheathed-element glow plug as recited in Claim 17, wherein the chip is applied in the housing without packaging.--

Remarks

This Preliminary Amendment cancels original Claims 1-9 of the underlying PCT application, as well as the substitute Claims 1-9 which are presented in the annex to the International Preliminary Examination Report, without prejudice. The Preliminary Amendment also adds new Claims 10-18. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §1.121(b)(3)(iii) and § 1.125(b)(2), a Marked-Up Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT application, PCT/DE00/02730 includes an International Search Report, dated February 5, 2001. A copy of the Search Report is annexed hereto. In addition, an English translation of an International Preliminary Examination Report (including the annex) is enclosed.

Applicants submit that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,
KENYON & KENYON

Dated: 3/14/02

By: R. Richard Mayer
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#457160v1

SHEATHED-ELEMENT GLOW PLUG

[Background Information] **FIELD OF THE INVENTION**

The present invention relates to a sheathed-element glow plug [as is] used in glow systems including a control unit and a glow plug for self-igniting combustion engines.

BACKGROUND INFORMATION

Glow plugs are known, for example, from **published** German [laid-open document] **Patent Application No.** DE 28 02 625. Such a sheathed-element glow plug includes a tubular metallic housing which bears a thread on its outer circumference, by way of which the sheathed-element glow plug is screwed into the cylinder. At the end of the housing of the sheathed-element glow plug nearest to the combustion chamber, a glow element is enclosed by the housing and cantilevered so that it reaches towards a sheathed-element glow plug built into the engine. A heating device is arranged in the glow element which, at the combustion chamber end, makes contact with the closed bottom of the glow element to make a ground connection, and at the end away from the combustion chamber makes contact with the supply voltage via a contact stud. Ceramic glow plugs are also known, in which the part reaching into the combustion chamber is made of ceramic. In the known glow systems, the current through the heating device is switched on or off by a preheating time control unit via a switch (relay, power transistor).

[Summary of the Invention]

SUMMARY OF THE INVENTION

The sheathed-element glow plug [having the characteristic features of the main claim, by comparison with the known arrangement,] **of this invention** has the advantage that the switch for switching the glow current on and off is integrated into the housing of the sheathed-element glow plug. Since this switch switches the current of only a single plug, it can be designed to be relatively small. Being positioned near the plug thread and thus having good coupling to the cylinder head also ensures good cooling for the operation of the plug, in the case of a cold engine before the start or during the warmup phase. In the case of

intermediate glow during prolonged overrun condition of the engine, the temperature at the plug threads is safely limited by the water cooling of the engine.

[Advantageous further embodiments of the sheathed-element glow plug according to the present invention and improvements thereto are rendered possible by the measures delineated in the dependent claims. The] **With this invention the** cost of installation of a cable system to the sheathed-type glow plug, having large cross sections, is considerably reduced. If an integrated switching part is built into the power switch, e.g. a SMART power switch, the total number of necessary electrical leads is also reduced. A separate preheating time control unit can be completely omitted under certain circumstances, or a more compact design is made possible. If the firing control is integrated into the housing of the sheathed-type glow plug, **then** there is **the** further [the] possibility of detecting and evaluating the glow temperature on the spot. Thereby, reaction to changes in the operating conditions can be very rapid and as good as possible. [Finally, if] **If** the preheating time control device ensures regulation of the glow temperature, **then** one can do without the control coil of the sheathed-type glow plug, which ensures by its positive temperature coefficient of resistance that the glow temperature does not reach inadmissibly high values. A further advantage [derives] **is derived** from the application of semiconductor chips as switching means. By building it into the housing of the sheathed-type glow plug, the chip is sufficiently protected from outside influences so that, when the semiconductor switch is built into the sheathed-element glow plug, the customary transistor [can] may be omitted, **thus** reducing costs.

[Brief Description of the Drawings

Exemplary embodiments of the present invention are represented in the drawings and are explained in detail in the following description. The figures show:

The figures show:]

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 **shows** a first exemplary embodiment **of the sheathed-element glow plug according to the present invention.**[,]

Figure 2 **shows** a second exemplary embodiment **of the sheathed-element glow plug according to the present invention.**[,]

Figure 3 **shows** a third exemplary embodiment **of the sheathed-element glow plug according to the present invention.**[,]

Figure 4 **shows** a fourth exemplary embodiment **of the sheathed-element glow plug according to the present invention.**[,]

Figure 5 **shows** a fifth exemplary embodiment of the sheathed-element glow plug according to the present invention[,].

Figures 6 & 8 **show** an arrangement of a glow system according to the present invention, having the glow plugs according to the present invention in a block diagram[,].

Figures 7 & 9 **show an** equivalent circuit diagrams for sheathed-element glow plug according to the present invention[, and].

Figure 10 **shows** a sixth exemplary embodiment of the sheathed-element glow plug according to the present invention.

[Description of the Exemplary Embodiments]

DETAILED DESCRIPTION

Figures 1 through 5 each show in cross section a sheathed-element glow plug for a self-igniting internal combustion engine**. The** [, the] basic construction of all the exemplary embodiments in Figures 1 through 5 **are** [being] the same, which is why the design principle is explained only once. The development of the integrated switch element, which is different in the exemplary embodiments in Figures 1 through 5, will [then] be explained directly in connection with each Figure.

The design principle of a sheathed-element glow plug as in Figures 1 through 5 includes a tubular metallic housing, in whose longitudinal bore a glow plug 11 is inserted with part of its length in a sealing manner. Glow plug 11 is made of a hot tube 12, closed at the combustion chamber end, in which a heating device extends in the axial direction, which includes a heating coil 14 positioned at the combustion chamber end, and a regulating coil 15 positioned in a direction away from the combustion chamber. The known heating coils are here shown as resistors, for simplification. The heating device is embedded in insulating material 16, and is thus insulated from the wall of hot tube 12. The design and mode of operation of such a sheathed-element glow plug are sufficiently well known from the related art cited at the outset, and will not be explained here in greater detail. Functionally, hot tube 12, along with

heating coils 14, represents a heating element projecting into the combustion chamber. Housing 10, together with insulating material 16 and regulating coil 15 represent an electrical feed-through as the supply line for electrical energy into the combustion chamber. Since we have the same basic design of the sheathed-element glow plug in Figures 1 through 5, the same components were given the same reference numerals.

In the sheathed-element glow plug according to the present invention as in Figure 1, a switch element is positioned in a housing 300 in housing 10 at the end away from the combustion chamber. In switch element 300 a switch is provided by which current flow through heating device [13] can be switched on and off. Switching element 300 is connected to supply **or connecting** lines 19 via plug contacts 301, via which a supply voltage and signals from a control unit, not shown here, are fed in. In this connection, the important thing is for a suitable temperature to prevail inside housing 10, for the use of semiconductor circuits. This comes about because the housing represents a current lead-through, through the wall of a cylinder of an internal combustion engine, and such cylinders are generally water-cooled. Since the housing is in direct contact with the wall of the cylinder, housing 10 and the inside of the housing are also cooled. Thus, semiconductor circuits can be used near or in the inner space of the housing for the switches according to the present invention.

The contacting of regulating coil 15 on the side away from the combustion chamber is done by a metallic connecting element 120. In Figure 1, only one such metallic connecting element 120 is shown, which has a flattened portion at the end of the plug away from the combustion chamber, i.e. towards connecting lines 19. On this flattened area switching element 300 is positioned, which is connected to the flattened side of connecting element 120, using, for instance, solder or a conductive adhesive. In the example according to Figure 1, switching element 300 is made up of a transistor which has a metallic drain terminal on its lower side and two terminal tags 301, which are connected to the source and the transistor gate. Apart from using a straight transistor, one may naturally also use every combination of semiconductor switch (transistor) having an "intelligent" circuit. The advantage of a packaged component is that these packaged components are especially easy to handle during the production of glow plugs.

Figure 2 shows a second exemplary embodiment, in which the switching element is designed as an unencapsulated silicon chip 302. Silicon chip 302 is positioned on an insulating layer 304, so that the lower side of the silicon chip is electrically insulated from the flattened area of connecting element 120. The connection to connecting lines 19 is made by bonding wires 303. An electrical connection to connecting element 120 is also made by bonding wires 303 from the upper side of silicon chip 302. It is advantageous here that unencapsulated silicon elements as a rule are cheaper than packaged components, use less space, and the fact that the housing of the glow plug itself represents sufficient packaging for silicon chip 302.

Figure 3 shows another exemplary embodiment of the glow plug according to the present invention. Here, connecting element 120 is designed as was described in connection with Figure 1, having a round part for contacting regulating coil 15, and having a part flattened towards the back on which, according to Figure 3, a semiconductor chip 302 without housing **is** positioned. Contacting the contact lines 19 takes place here again by using bonding wires 303 fastened to the upper side of semiconductor chip 302, and thus creating a connection to contact lines 19. The electrical contact to metallic connecting element 120 takes place simply in that semiconductor chip 302 **which** is positioned with its back side directly on the area of metallic connecting element 120 which is flattened towards the back. Semiconductor chip 302 includes a power transistor whose drain connection is formed by the back side of semiconductor chip 302.

The example as in Figure 4 differs from the one in Figure 3 only in that the last piece of contact lines 19 is designed in such a way that they can be fastened directly to the surface of chip 302. This can be done, for example, by having the last piece of contact lines 19 developed as thin sheet metal pieces which can be soldered directly to the surface of semiconductor chip 302 via appropriate soldering points 305.

In Figure 5, a connecting element 120 is used which is completely rotationally symmetrical and has a completely flattened side on the side opposite the combustion chamber. On this flattened side, semiconductor chip 302 is mounted, so that once again an electrical contact is established between the lower side of semiconductor chip 302 and connecting element 120. On the upper side of semiconductor chip 302 soldering globules 305 are again provided, for contacting connecting lines 19.

Figure 6 shows a block diagram of the entire glow system, including control device 60 and glow plugs 61. Control device 60 is here connected to glow plugs 61 over a common line 19. The glow plugs are also connected to supply voltage 200 via a further line 19.

Figure 7 shows an equivalent circuit diagram of a sheathed-element glow plug as in Figure 6. A switch 70 is connected at one terminal to supply voltage 200, and at the other, in series, to regulating coil 15 and heating coil 14 to ground connection 201. Switch 70 is opened or closed by an activating circuit 73 via an appropriate line, activating circuit 73 receiving corresponding signals from control unit 60 via line 19. Activating circuit 73 also receives an operating current from supply terminal 200.

As can be seen in Figure 6, all the **glow** plugs **61** are connected to control device 60 by a line 19. By appropriately coded bit sequences, frequency signals, etc, the glow plugs **61** can be individually activated by control device 60 in spite of this common wiring, if this is required for individual operating conditions, or for diagnostic purposes. However, in normal operation, the glow plugs as a rule are all activated in common.

The sheathed-element glow plugs described in Figures 1 through 7 thus have three electrical terminals, ground connection 201 being as a rule implemented by housing 10. Supply terminal 200 supplies the electrical current which delivers the electrical energy for heating via switch 70. Finally, the switching state of switch 70 is determined by a third electrical connection. Usually, customary p or n channel power MOSFETS can be used for switch 70. Activating circuit 73 and switch 70 are integrated on one semiconductor chip.

Connecting line 19 between control unit 60 and sheathed-element glow plugs 61 can also be used for the return of data from glow plugs 61 to control device 60. Control circuit 73 must then be furnished with correspondingly more intelligence, i.e. it must be in a position to transmit back certain data from the individual sheathed-element glow plugs to control unit 60. This function can also be activated, for example, [only] for diagnostic purposes **only**, meaning that in a particular operating state, an individual interrogation of individual sheathed-element glow plugs 61 is performed, regarding the functions detected by them.

In Figure 8 a further interconnection of a control unit 60 with sheathed-element glow plugs 61 is shown. In this case, sheathed-element glow plugs 61 [have] only **have** a single connection for connecting to control unit 60 via line 19. Control unit 60 makes available the necessary operating energy for operating glow plugs 61 via line 19. The control signal for the circuit is additionally modulated upon line 19. In this case, both switch 70 and evaluation circuit 73 are connected to one connecting line. [Then] **With this embodiment,** on line 19 there is always a voltage level which is sufficient for operating sheathed-element glow plugs 61**. The** [,] control circuit 73 [recognizing] **recognizes** from additional voltage impulses that switch 70 [is] **can** now [to] be operated. This can be done using bit sequences of frequency signals which are then recognized by control circuit 73. A simple example can be that a higher-frequency signal is simply superimposed on the usual voltage level, which is then recognized by control circuit 73 and leads to the closing of switch 70.

Figure 9 shows a further advantageous circuit example, which starts from a terminal 200 for the operating voltage and a line 19 for the control signals of control unit 60. Switch element 73 here receives the control signals from control unit 60 and a supply voltage from terminal 200. Switch 70 is here positioned in series with voltage supply 200, heating coil 14 and ground terminal 201. However, in contrast to the examples up to now, one does without the use of a regulating coil **15**, and only a heating coil 14 is provided. The function of regulating coil **15** is to limit the current flow through heating coil 14 after a certain warmup period. This is done by selecting a material for the regulating coil **15** whose resistance increases with increasing temperature. Because of the direct positioning of an intelligent control circuit 73 in the direct vicinity of the actual heating element, the function of the regulating coil **15** can be taken over by control circuit 73. In this connection, a temperature measuring element can then be arranged on the semiconductor chip which measures the temperature of the sheathed-element glow plug. The temperature of the sheathed-element glow plug at the location of the semiconductor chip depends on the temperature at the tip of the glow plug, so that one can determine the temperature at the tip of the glow plug from the temperature measured at the semiconductor chip. Other possibilities for determining the temperature of the sheathed-element glow plug are measuring the temperature of the heating element. The temperature of the heating element can be measured if the heating resistance has a temperature dependence on the resistance. The temperature of the glow plug **61** can then be determined by measuring the resistance of the heating element. Furthermore, other

temperature-sensitive measuring elements can also be provided which can be positioned near the heating element. The control circuit **73** is then designed so that it limits current flow through heating coil 14 as a function of the measured temperature. This can be done, for instance, by pulse modulation, i.e., as a function of the temperature variation, control circuit 73 opens or closes switch 70 so as to set a desired temperature in heating coil 14. Using this measure would decisively simplify the design of the glow plug **61**. Instead of using temperature measurement, the temperature of the glow plugs **61** can also be indirectly [concluded] **determined** from current flow through the heating coil **14**, current flow through the heating coil **14** integrated over time, resistance of the heating coil **14** or other methods. Thus, these methods are technically equivalent.

In Figure 10, a further embodiment of the sheathed-element glow plug according to the present invention, [is shown, in] Figure 10 **shows** a [so-called] ceramic sheathed-element glow plug [being shown]. In such a ceramic sheathed-element glow plug, hot tube **12** [11] is made up of a first and a second conductive ceramic layer 501, 502, between which an insulating ceramic layer 503 is arranged. At the tip of hot tube **12** [11], the first and the second conductive ceramic layers 501, 502 are connected to each other in a thinned-down tip region 504, so that current flow is possible from ceramic conductive layer 501 to second conductive ceramic layer 502 via thinned-down tip region 504. Hot tube **12** [11], in turn, is held by a housing 10, at the end opposite the combustion chamber. As can be recognized in Figure 10, first ceramic conductive layer 501 extends further to the right in housing 10, and a chip 302 is then applied to this area, which is connected to a supply line 19 by a bonding wire 303. In chip **302** [202], in turn, a vertical transistor is arranged, which makes possible a current flow from the upper side of chip **302** [202] to the lower side of chip **302** [202], so that an electrical current can be fed to first conductive layer 501 via chip **302** [202]. The ceramic layers are here entirely coated with a thin superficial glass layer, which is only removed in the area under silicon chip 302 and in contact area 505, where electrical contact is established between the second conductive ceramic layer 502 and housing 10. On account of the technologies used for producing ceramic sheathed-element glow plugs, these plugs are particularly suitable for accommodating silicon chips.

[Abstract

A sheathed-element glow plug for self-igniting internal combustion engines is proposed, having an electrical heating element projecting into a combustion chamber of the internal combustion engine and having a current feed-through for feeding a heating current for the heating element through an opening in the combustion chamber. A switch is positioned in the region of the current feed-through, and the heating current may be controlled by the opening and closing of the switch.

(Figure 1)]

ABSTRACT OF THE DISCLOSURE

A sheathed-element glow plug for self-igniting internal combustion engines has an electrical heating element which projects into a combustion chamber of the internal combustion engine, and a current feed-through for providing a heating current for the heating element through an opening in the combustion chamber. A switch is positioned in the region of the current feed-through, and the heating current may be controlled by the opening and closing of the switch.

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6/PRTS

[10191/2327]

SHEATHED-ELEMENT GLOW PLUG

FIELD OF THE INVENTION

The present invention relates to a sheathed-element glow plug used in glow systems including a control unit and a glow plug for self-igniting combustion engines.

BACKGROUND INFORMATION

Glow plugs are known, for example, from published German Patent Application No. DE 28 02 625. Such a sheathed-element glow plug includes a tubular metallic housing which bears a thread on its outer circumference, by way of which the sheathed-element glow plug is screwed into the cylinder. At the end of the housing of the sheathed-element glow plug nearest to the combustion chamber, a glow element is enclosed by the housing and cantilevered so that it reaches towards a sheathed-element glow plug built into the engine. A heating device is arranged in the glow element which, at the combustion chamber end, makes contact with the closed bottom of the glow element to make a ground connection, and at the end away from the combustion chamber makes contact with the supply voltage via a contact stud. Ceramic glow plugs are also known, in which the part reaching into the combustion chamber is made of ceramic. In the known glow systems, the current through the heating device is switched on or off by a preheating time control unit via a switch (relay, power transistor).

SUMMARY OF THE INVENTION

The sheathed-element glow plug of this invention has the advantage that the switch for switching the glow current on and off is integrated into the housing of the sheathed-element glow plug. Since this switch switches the current of only a single plug, it can be designed to be relatively small. Being positioned near the plug thread and thus having good coupling to the cylinder head also ensures good cooling for the operation of the plug, in the case of a cold engine before the start or during the warmup phase. In the case of intermediate glow during prolonged overrun condition of the engine, the temperature at the plug threads is safely limited by the water cooling of the engine.

With this invention the cost of installation of a cable system to the sheathed-type glow plug, having large cross sections, is considerably reduced. If an integrated switching part is built into the power switch, e.g. a SMART power switch, the total number of necessary electrical leads is also reduced. A separate preheating time control unit can be completely omitted under certain circumstances, or a more compact design is made possible. If the firing control is integrated into the housing of the sheathed-type glow plug, then there is the further possibility of detecting and evaluating the glow temperature on the spot. Thereby, reaction to changes in the operating conditions can be very rapid and as good as possible. If the preheating time control device ensures regulation of the glow temperature, then one can do without the control coil of the sheathed-type glow plug, which ensures by its positive temperature coefficient of resistance that the glow temperature does not reach inadmissibly high values. A further advantage is derived from the application of semiconductor chips as switching means. By building it into the housing of the sheathed-type glow plug, the chip is sufficiently protected from outside influences so that, when the semiconductor switch is built into the sheathed-element glow plug, the customary transistor may be omitted, thus reducing costs.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a first exemplary embodiment of the sheathed-element glow plug according to the present invention.

Figure 2 shows a second exemplary embodiment of the sheathed-element glow plug according to the present invention.

Figure 3 shows a third exemplary embodiment of the sheathed-element glow plug according to the present invention.

Figure 4 shows a fourth exemplary embodiment of the sheathed-element glow plug according to the present invention.

Figure 5 shows a fifth exemplary embodiment of the sheathed-element glow plug according to the present invention.

Figures 6 & 8 show an arrangement of a glow system according to the present invention, having the glow plugs according to the present invention in a block diagram.

Figures 7 & 9 show an equivalent circuit diagrams for sheathed-element glow plug according to the present invention.

Figure 10 shows a sixth exemplary embodiment of the sheathed-element glow plug according to the present invention.

DETAILED DESCRIPTION

Figures 1 through 5 each show in cross section a sheathed-element glow plug for a self-igniting internal combustion engine. The basic construction of all the exemplary embodiments in Figures 1 through 5 are the same, which is why the design principle is explained only once. The development of the integrated switch element, which is different in the exemplary embodiments in Figures 1 through 5, will be explained directly in connection with each Figure.

The design principle of a sheathed-element glow plug as in Figures 1 through 5 includes a tubular metallic housing, in whose longitudinal bore a glow plug 11 is inserted with part of its length in a sealing manner. Glow plug 11 is made of a hot tube 12, closed at the combustion chamber end, in which a heating device extends in the axial direction, which includes a heating coil 14 positioned at the combustion chamber end, and a regulating coil 15 positioned in a direction away from the combustion chamber. The known heating coils are here shown as resistors, for simplification. The heating device is embedded in insulating material 16, and is thus insulated from the wall of hot tube 12. The design and mode of operation of such a sheathed-element glow plug are sufficiently well known from the related art cited at the outset, and will not be explained here in greater detail. Functionally, hot tube 12, along with heating coils 14, represents a heating element projecting into the combustion chamber. Housing 10, together with insulating material 16 and regulating coil 15 represent an electrical feed-through as the supply line for electrical energy into the combustion chamber. Since we have the same basic design of the sheathed-element glow plug in Figures 1 through 5, the same components were given the same reference numerals.

In the sheathed-element glow plug according to the present invention as in Figure 1, a switch element is positioned in a housing 300 in housing 10 at the end away from the combustion chamber. In switch element 300 a switch is provided by which current flow through heating device can be switched on and off. Switching element 300 is connected to supply or connecting lines 19 via plug contacts 301, via which a supply voltage and signals from a control unit, not shown here, are fed in. In this connection, the important thing is for a

suitable temperature to prevail inside housing 10, for the use of semiconductor circuits. This comes about because the housing represents a current lead-through, through the wall of a cylinder of an internal combustion engine, and such cylinders are generally water-cooled. Since the housing is in direct contact with the wall of the cylinder, housing 10 and the inside of the housing are also cooled. Thus, semiconductor circuits can be used near or in the inner space of the housing for the switches according to the present invention.

The contacting of regulating coil 15 on the side away from the combustion chamber is done by a metallic connecting element 120. In Figure 1, only one such metallic connecting element 120 is shown, which has a flattened portion at the end of the plug away from the combustion chamber, i.e. towards connecting lines 19. On this flattened area switching element 300 is positioned, which is connected to the flattened side of connecting element 120, using, for instance, solder or a conductive adhesive. In the example according to Figure 1, switching element 300 is made up of a transistor which has a metallic drain terminal on its lower side and two terminal tags 301, which are connected to the source and the transistor gate. Apart from using a straight transistor, one may naturally also use every combination of semiconductor switch (transistor) having an "intelligent" circuit. The advantage of a packaged component is that these packaged components are especially easy to handle during the production of glow plugs.

Figure 2 shows a second exemplary embodiment, in which the switching element is designed as an unencapsulated silicon chip 302. Silicon chip 302 is positioned on an insulating layer 304, so that the lower side of the silicon chip is electrically insulated from the flattened area of connecting element 120. The connection to connecting lines 19 is made by bonding wires 303. An electrical connection to connecting element 120 is also made by bonding wires 303 from the upper side of silicon chip 302. It is advantageous here that unencapsulated silicon elements as a rule are cheaper than packaged components, use less space, and the fact that the housing of the glow plug itself represents sufficient packaging for silicon chip 302.

Figure 3 shows another exemplary embodiment of the glow plug according to the present invention. Here, connecting element 120 is designed as was described in connection with Figure 1, having a round part for contacting regulating coil 15, and having a part flattened towards the back on which, according to Figure 3, a semiconductor chip 302 without housing

is positioned. Contacting the contact lines 19 takes place here again by using bonding wires 303 fastened to the upper side of semiconductor chip 302, and thus creating a connection to contact lines 19. The electrical contact to metallic connecting element 120 takes place simply in that semiconductor chip 302 which is positioned with its back side directly on the area of metallic connecting element 120 which is flattened towards the back. Semiconductor chip 302 includes a power transistor whose drain connection is formed by the back side of semiconductor chip 302.

The example as in Figure 4 differs from the one in Figure 3 only in that the last piece of contact lines 19 is designed in such a way that they can be fastened directly to the surface of chip 302. This can be done, for example, by having the last piece of contact lines 19 developed as thin sheet metal pieces which can be soldered directly to the surface of semiconductor chip 302 via appropriate soldering points 305.

In Figure 5, a connecting element 120 is used which is completely rotationally symmetrical and has a completely flattened side on the side opposite the combustion chamber. On this flattened side, semiconductor chip 302 is mounted, so that once again an electrical contact is established between the lower side of semiconductor chip 302 and connecting element 120. On the upper side of semiconductor chip 302 soldering globules 305 are again provided, for contacting connecting lines 19.

Figure 6 shows a block diagram of the entire glow system, including control device 60 and glow plugs 61. Control device 60 is here connected to glow plugs 61 over a common line 19. The glow plugs are also connected to supply voltage 200 via a further line 19.

Figure 7 shows an equivalent circuit diagram of a sheathed-element glow plug as in Figure 6. A switch 70 is connected at one terminal to supply voltage 200, and at the other, in series, to regulating coil 15 and heating coil 14 to ground connection 201. Switch 70 is opened or closed by an activating circuit 73 via an appropriate line, activating circuit 73 receiving corresponding signals from control unit 60 via line 19. Activating circuit 73 also receives an operating current from supply terminal 200.

As can be seen in Figure 6, all the glow plugs 61 are connected to control device 60 by a line 19. By appropriately coded bit sequences, frequency signals, etc, the glow plugs 61 can be individually activated by control device 60 in spite of this common wiring, if this is required for individual operating conditions, or for diagnostic purposes. However, in normal operation, the glow plugs as a rule are all activated in common.

The sheathed-element glow plugs described in Figures 1 through 7 thus have three electrical terminals, ground connection 201 being as a rule implemented by housing 10. Supply terminal 200 supplies the electrical current which delivers the electrical energy for heating via switch 70. Finally, the switching state of switch 70 is determined by a third electrical connection. Usually, customary p or n channel power MOSFETS can be used for switch 70. Activating circuit 73 and switch 70 are integrated on one semiconductor chip.

Connecting line 19 between control unit 60 and sheathed-element glow plugs 61 can also be used for the return of data from glow plugs 61 to control device 60. Control circuit 73 must then be furnished with correspondingly more intelligence, i.e. it must be in a position to transmit back certain data from the individual sheathed-element glow plugs to control unit 60. This function can also be activated, for example, for diagnostic purposes only, meaning that in a particular operating state, an individual interrogation of individual sheathed-element glow plugs 61 is performed, regarding the functions detected by them.

In Figure 8 a further interconnection of a control unit 60 with sheathed-element glow plugs 61 is shown. In this case, sheathed-element glow plugs 61 only have a single connection for connecting to control unit 60 via line 19. Control unit 60 makes available the necessary operating energy for operating glow plugs 61 via line 19. The control signal for the circuit is additionally modulated upon line 19. In this case, both switch 70 and evaluation circuit 73 are connected to one connecting line. With this embodiment, on line 19 there is always a voltage level which is sufficient for operating sheathed-element glow plugs 61. The control circuit 73 recognizes from additional voltage impulses that switch 70 can now be operated. This can be done using bit sequences of frequency signals which are then recognized by control circuit 73. A simple example can be that a higher-frequency signal is simply superimposed on the usual voltage level, which is then recognized by control circuit 73 and leads to the closing of switch 70.

Figure 9 shows a further advantageous circuit example, which starts from a terminal 200 for the operating voltage and a line 19 for the control signals of control unit 60. Switch element 73 here receives the control signals from control unit 60 and a supply voltage from terminal 200. Switch 70 is here positioned in series with voltage supply 200, heating coil 14 and ground terminal 201. However, in contrast to the examples up to now, one does without the use of a regulating coil 15, and only a heating coil 14 is provided. The function of regulating coil 15 is to limit the current flow through heating coil 14 after a certain warmup period. This is done by selecting a material for the regulating coil 15 whose resistance increases with increasing temperature. Because of the direct positioning of an intelligent control circuit 73 in the direct vicinity of the actual heating element, the function of the regulating coil 15 can be taken over by control circuit 73. In this connection, a temperature measuring element can then be arranged on the semiconductor chip which measures the temperature of the sheathed-element glow plug. The temperature of the sheathed-element glow plug at the location of the semiconductor chip depends on the temperature at the tip of the glow plug, so that one can determine the temperature at the tip of the glow plug from the temperature measured at the semiconductor chip. Other possibilities for determining the temperature of the sheathed-element glow plug are measuring the temperature of the heating element. The temperature of the heating element can be measured if the heating resistance has a temperature dependence on the resistance. The temperature of the glow plug 61 can then be determined by measuring the resistance of the heating element. Furthermore, other temperature-sensitive measuring elements can also be provided which can be positioned near the heating element. The control circuit 73 is then designed so that it limits current flow through heating coil 14 as a function of the measured temperature. This can be done, for instance, by pulse modulation, i.e., as a function of the temperature variation, control circuit 73 opens or closes switch 70 so as to set a desired temperature in heating coil 14. Using this measure would decisively simplify the design of the glow plug 61. Instead of using temperature measurement, the temperature of the glow plugs 61 can also be indirectly determined from current flow through the heating coil 14, current flow through the heating coil 14 integrated over time, resistance of the heating coil 14 or other methods. Thus, these methods are technically equivalent.

In Figure 10, a further embodiment of the sheathed-element glow plug according to the present invention. Figure 10 shows a ceramic sheathed-element glow plug. In such a

ceramic sheathed-element glow plug, hot tube 12 is made up of a first and a second conductive ceramic layer 501, 502, between which an insulating ceramic layer 503 is arranged. At the tip of hot tube 12, the first and the second conductive ceramic layers 501, 502 are connected to each other in a thinned-down tip region 504, so that current flow is possible from ceramic conductive layer 501 to second conductive ceramic layer 502 via thinned-down tip region 504. Hot tube 12, in turn, is held by a housing 10, at the end opposite the combustion chamber. As can be recognized in Figure 10, first ceramic conductive layer 501 extends further to the right in housing 10, and a chip 302 is then applied to this area, which is connected to a supply line 19 by a bonding wire 303. In chip 302, in turn, a vertical transistor is arranged, which makes possible a current flow from the upper side of chip 302 to the lower side of chip 302, so that an electrical current can be fed to first conductive layer 501 via chip 302. The ceramic layers are here entirely coated with a thin superficial glass layer, which is only removed in the area under silicon chip 302 and in contact area 505, where electrical contact is established between the second conductive ceramic layer 502 and housing 10. On account of the technologies used for producing ceramic sheathed-element glow plugs, these plugs are particularly suitable for accommodating silicon chips.

ABSTRACT OF THE DISCLOSURE

A sheathed-element glow plug for self-igniting internal combustion engines has an electrical heating element which projects into a combustion chamber of the internal combustion engine, and a current feed-through for providing a heating current for the heating element through an opening in the combustion chamber. A switch is positioned in the region of the current feed-through, and the heating current may be controlled by the opening and closing of the switch.

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SHEATHED-ELEMENT GLOW PLUG

Background Information

The present invention relates to a sheathed-element glow plug as is used in glow systems including a control unit and a glow plug for self-igniting combustion engines. Glow plugs are known, for example, from German laid-open document DE 28 02 625. Such a sheathed-element glow plug includes a tubular metallic housing which bears a thread on its outer circumference, by way of which the sheathed-element glow plug is screwed into the cylinder. At the end of the housing of the sheathed-element glow plug nearest to the combustion chamber, a glow element is enclosed by the housing and cantilevered so that it reaches towards a sheathed-element glow plug built into the engine. A heating device is arranged in the glow element which, at the combustion chamber end, makes contact with the closed bottom of the glow element to make a ground connection, and at the end away from the combustion chamber makes contact with the supply voltage via a contact stud. Ceramic glow plugs are also known, in which the part reaching into the combustion chamber is made of ceramic. In the known glow systems, the current through the heating device is switched on or off by a preheating time control unit via a switch (relay, power transistor).

Summary of the Invention

The sheathed-element glow plug having the characteristic features of the main claim, by comparison with the known

arrangement, has the advantage that the switch for switching the glow current on and off is integrated into the housing of the sheathed-element glow plug. Since this switch switches the current of only a single plug, it can be designed to be relatively small. Being positioned near the plug thread and thus having good coupling to the cylinder head also ensures good cooling for the operation of the plug, in the case of a cold engine before the start or during the warmup phase. In the case of intermediate glow during prolonged overrun condition of the engine, the temperature at the plug threads is safely limited by the water cooling of the engine.

Advantageous further embodiments of the sheathed-element glow plug according to the present invention and improvements thereto are rendered possible by the measures delineated in the dependent claims. The cost of installation of a cable system to the sheathed-type glow plug, having large cross sections, is considerably reduced. If an integrated switching part is built into the power switch, e.g. a SMART power switch, the total number of necessary electrical leads is also reduced. A separate preheating time control unit can be completely omitted under certain circumstances, or a more compact design is made possible. If the firing control is integrated into the housing of the sheathed-type glow plug, there is further the possibility of detecting and evaluating the glow temperature on the spot. Thereby, reaction to changes in the operating conditions can be very rapid and as good as possible. Finally, if the preheating time control device ensures regulation of the glow temperature, one can do without the control coil of the sheathed-type glow plug, which ensures by its positive temperature coefficient of resistance that the glow temperature does not reach inadmissibly high values. A further advantage derives from the application of semiconductor chips as switching means. By building it into the housing of the sheathed-type glow plug, the chip is

sufficiently protected from outside influences so that, when the semiconductor switch is built into the sheathed-element glow plug, the customary transistor can may be omitted, reducing costs.

Brief Description of the Drawings

Exemplary embodiments of the present invention are represented in the drawings and are explained in detail in the following description. The figures show:

The figures show:

Figure 1	a first exemplary embodiment,
Figure 2	a second exemplary embodiment,
Figure 3	a third exemplary embodiment,
Figure 4	a fourth exemplary embodiment,
Figure 5	a fifth exemplary embodiment of the sheathed-element glow plug according to the present invention,
Figures 6 & 8	an arrangement of a glow system according to the present invention, having the glow plugs according to the present invention in a block diagram,
Figures 7 & 9	equivalent circuit diagrams for sheathed-element glow plug according to the present invention, and
Figure 10	a sixth exemplary embodiment of the sheathed-element glow plug according to the present invention.

Description of the Exemplary Embodiments

Figures 1 through 5 each show in cross section a sheathed-element glow plug for a self-igniting internal

combustion engine, the basic construction of all the exemplary embodiments in Figures 1 through 5 being the same, which is why the design principle is explained only once. The development of the integrated switch element, which is different in the exemplary embodiments in Figures 1 through 5, will then be explained directly in connection with each Figure.

The design principle of a sheathed-element glow plug as in Figures 1 through 5 includes a tubular metallic housing, in whose longitudinal bore a glow plug 11 is inserted with part of its length in a sealing manner. Glow plug 11 is made of a hot tube 12, closed at the combustion chamber end, in which a heating device extends in the axial direction, which includes a heating coil 14 positioned at the combustion chamber end, and a regulating coil 15 positioned in a direction away from the combustion chamber. The known heating coils are here shown as resistors, for simplification. The heating device is embedded in insulating material 16, and is thus insulated from the wall of hot tube 12. The design and mode of operation of such a sheathed-element glow plug are sufficiently well known from the related art cited at the outset, and will not be explained here in greater detail. Functionally, hot tube 12, along with heating coils 14, represents a heating element projecting into the combustion chamber. Housing 10, together with insulating material 16 and regulating coil 15 represent an electrical feed-through as the supply line for electrical energy into the combustion chamber. Since we have the same basic design of the sheathed-element glow plug in Figures 1 through 5, the same components were given the same reference numerals.

In the sheathed-element glow plug according to the present invention as in Figure 1, a switch element is positioned in a housing 300 in housing 10 at the end away from the combustion

chamber. In switch element 300 a switch is provided by which current flow through heating device 13 can be switched on and off. Switching element 300 is connected to supply lines 19 via plug contacts 301, via which a supply voltage and signals from a control unit, not shown here, are fed in. In this connection, the important thing is for a suitable temperature to prevail inside housing 10, for the use of semiconductor circuits. This comes about because the housing represents a current lead-through, through the wall of a cylinder of an internal combustion engine, and such cylinders are generally water-cooled. Since the housing is in direct contact with the wall of the cylinder, housing 10 and the inside of the housing are also cooled. Thus, semiconductor circuits can be used near or in the inner space of the housing for the switches according to the present invention.

The contacting of regulating coil 15 on the side away from the combustion chamber is done by a metallic connecting element 120. In Figure 1, only one such metallic connecting element 120 is shown, which has a flattened portion at the end of the plug away from the combustion chamber, i.e. towards connecting lines 19. On this flattened area switching element 300 is positioned, which is connected to the flattened side of connecting element 120, using, for instance, solder or a conductive adhesive. In the example according to Figure 1, switching element 300 is made up of a transistor which has a metallic drain terminal on its lower side and two terminal tags 301, which are connected to the source and the transistor gate. Apart from using a straight transistor, one may naturally also use every combination of semiconductor switch (transistor) having an "intelligent" circuit. The advantage of a packaged component is that these packaged components are especially easy to handle during the production of glow plugs.

Figure 2 shows a second exemplary embodiment, in which the

switching element is designed as an unencapsulated silicon chip 302. Silicon chip 302 is positioned on an insulating layer 304, so that the lower side of the silicon chip is electrically insulated from the flattened area of connecting element 120. The connection to connecting lines 19 is made by bonding wires 303. An electrical connection to connecting element 120 is also made by bonding wires 303 from the upper side of silicon chip 302. It is advantageous here that unencapsulated silicon elements as a rule are cheaper than packaged components, use less space, and the fact that the housing of the glow plug itself represents sufficient packaging for silicon chip 302.

Figure 3 shows another exemplary embodiment of the glow plug according to the present invention. Here, connecting element 120 is designed as was described in connection with Figure 1, having a round part for contacting regulating coil 15, and having a part flattened towards the back on which, according to Figure 3, a semiconductor chip 302 without housing positioned. Contacting the contact lines 19 takes place here again by using bonding wires 303 fastened to the upper side of semiconductor chip 302, and thus creating a connection to contact lines 19. The electrical contact to metallic connecting element 120 takes place simply in that semiconductor chip 302 is positioned with its back side directly on the area of metallic connecting element 120 which is flattened towards the back. Semiconductor chip 302 includes a power transistor whose drain connection is formed by the back side of semiconductor chip 302.

The example as in Figure 4 differs from the one in Figure 3 only in that the last piece of contact lines 19 is designed in such a way that they can be fastened directly to the surface of chip 302. This can be done, for example, by having the last piece of contact lines 19 developed as thin sheet metal pieces

which can be soldered directly to the surface of semiconductor chip 302 via appropriate soldering points 305.

In Figure 5, a connecting element 120 is used which is completely rotationally symmetrical and has a completely flattened side on the side opposite the combustion chamber. On this flattened side, semiconductor chip 302 is mounted, so that once again an electrical contact is established between the lower side of semiconductor chip 302 and connecting element 120. On the upper side of semiconductor chip 302 soldering globules 305 are again provided, for contacting connecting lines 19.

Figure 6 shows a block diagram of the entire glow system, including control device 60 and glow plugs 61. Control device 60 is here connected to glow plugs 61 over a common line 19. The glow plugs are also connected to supply voltage 200 via a further line 19.

Figure 7 shows an equivalent circuit diagram of a sheathed-element glow plug as in Figure 6. A switch 70 is connected at one terminal to supply voltage 200, and at the other, in series, to regulating coil 15 and heating coil 14 to ground connection 201. Switch 70 is opened or closed by an activating circuit 73 via an appropriate line, activating circuit 73 receiving corresponding signals from control unit 60 via line 19. Activating circuit 73 also receives an operating current from supply terminal 200.

As can be seen in Figure 6, all the plugs are connected to control device 60 by a line 19. By appropriately coded bit sequences, frequency signals, etc, the glow plugs can be individually activated by control device 60 in spite of this common wiring, if this is required for individual operating conditions, or for diagnostic purposes. However, in normal

operation, the glow plugs as a rule are all activated in common.

The sheathed-element glow plugs described in Figures 1 through 7 thus have three electrical terminals, ground connection 201 being as a rule implemented by housing 10. Supply terminal 200 supplies the electrical current which delivers the electrical energy for heating via switch 70. Finally, the switching state of switch 70 is determined by a third electrical connection. Usually, customary p or n channel power MOSFETS can be used for switch 70. Activating circuit 73 and switch 70 are integrated on one semiconductor chip.

Connecting line 19 between control unit 60 and sheathed-element glow plugs 61 can also be used for the return of data from glow plugs 61 to control device 60. Control circuit 73 must then be furnished with correspondingly more intelligence, i.e. it must be in a position to transmit back certain data from the individual sheathed-element glow plugs to control unit 60. This function can also be activated, for example, only for diagnostic purposes, meaning that in a particular operating state, an individual interrogation of individual sheathed-element glow plugs 61 is performed, regarding the functions detected by them.

In Figure 8 a further interconnection of a control unit 60 with sheathed-element glow plugs 61 is shown. In this case, sheathed-element glow plugs 61 have only a single connection for connecting to control unit 60 via line 19. Control unit 60 makes available the necessary operating energy for operating glow plugs 61 via line 19. The control signal for the circuit is additionally modulated upon line 19. In this case, both switch 70 and evaluation circuit 73 are connected to one connecting line. Then on line 19 there is always a voltage level which is sufficient for operating sheathed-element glow

plugs 61, control circuit 73 recognizing from additional voltage impulses that switch 70 is now to be operated. This can be done using bit sequences of frequency signals which are then recognized by control circuit 73. A simple example can be that a higher-frequency signal is simply superimposed on the usual voltage level, which is then recognized by control circuit 73 and leads to the closing of switch 70.

Figure 9 shows a further advantageous circuit example, which starts from a terminal 200 for the operating voltage and a line 19 for the control signals of control unit 60. Switch element 73 here receives the control signals from control unit 60 and a supply voltage from terminal 200. Switch 70 is here positioned in series with voltage supply 200, heating coil 14 and ground terminal 201. However, in contrast to the examples up to now, one does without the use of a regulating coil, and only a heating coil 14 is provided. The function of regulating coil is to limit the current flow through heating coil 14 after a certain warmup period. This is done by selecting a material for the regulating coil whose resistance increases with increasing temperature. Because of the direct positioning of an intelligent control circuit 73 in the direct vicinity of the actual heating element, the function of the regulating coil can be taken over by control circuit 73. In this connection, a temperature measuring element can then be arranged on the semiconductor chip which measures the temperature of the sheathed-element glow plug. The temperature of the sheathed-element glow plug at the location of the semiconductor chip depends on the temperature at the tip of the glow plug, so that one can determine the temperature at the tip of the glow plug from the temperature measured at the semiconductor chip. Other possibilities for determining the temperature of the sheathed-element glow plug are measuring the temperature of the heating element. The temperature of the heating element can be measured if the heating resistance has

a temperature dependence on the resistance. The temperature of the glow plug can then be determined by measuring the resistance of the heating element. Furthermore, other temperature-sensitive measuring elements can also be provided which can be positioned near the heating element. The control circuit is then designed so that it limits current flow through heating coil 14 as a function of the measured temperature. This can be done, for instance, by pulse modulation, i.e., as a function of the temperature variation, control circuit 73 opens or closes switch 70 so as to set a desired temperature in heating coil 14. Using this measure would decisively simplify the design of the glow plug. Instead of using temperature measurement, the temperature of the glow plugs can also be indirectly concluded from current flow through the heating coil, current flow through the heating coil integrated over time, resistance of the heating coil or other methods. Thus, these methods are technically equivalent.

In Figure 10, a further embodiment of the sheathed-element glow plug according to the present invention is shown, in Figure 10 a so-called ceramic sheathed-element glow plug being shown. In such a ceramic sheathed-element glow plug, hot tube 11 is made up of a first and a second conductive ceramic layer 501, 502, between which an insulating ceramic layer 503 is arranged. At the tip of hot tube 11, the first and the second conductive ceramic layers 501, 502 are connected to each other in a thinned-down tip region 504, so that current flow is possible from ceramic conductive layer 501 to second conductive ceramic layer 502 via thinned-down tip region 504. Hot tube 11, in turn, is held by a housing 10, at the end opposite the combustion chamber. As can be recognized in Figure 10, first ceramic conductive layer 501 extends further to the right in housing 10, and a chip 302 is then applied to this area, which is connected to a supply line 19 by a bonding wire 303. In chip 202, in turn, a vertical transistor is

arranged, which makes possible a current flow from the upper side of chip 202 to the lower side of chip 202, so that an electrical current can be fed to first conductive layer 501 via chip 202. The ceramic layers are here entirely coated with a thin superficial glass layer, which is only removed in the area under silicon chip 302 and in contact area 505, where electrical contact is established between the second conductive ceramic layer 502 and housing 10. On account of the technologies used for producing ceramic sheathed-element glow plugs, these plugs are particularly suitable for accommodating silicon chips.

What is claimed is:

1. A sheathed-element glow plug for a self-igniting internal combustion engine, having a heating element projecting into a combustion chamber of the internal combustion engine, having a current feed-through (10) by which a heating current for the heating element is fed through an opening in the combustion chamber,
wherein a switch is positioned in the region of the current feed-through (10); and the heating current may be controlled by opening and closing of the switch.

2. The sheathed-element glow plug as recited in Claim 1, wherein a control circuit (73) for the switch is positioned in the region of the current feed-through (10); and a signal may be produced by the control circuit (73) for opening and closing the switch.

3. The sheathed-element glow plug as recited in Claim 2, wherein two feed lines (19) are provided, a first supply line (19) may be connected to a terminal for a supply voltage for the heating current; and a second line (19) is connected to the control circuit (73); and a control signal may be applied to the control circuit (73) via the second line (19).

4. The control circuit as recited in Claim 2,
wherein an input for a line (19) is provided; the input is connected to the switch (70) and the control circuit (73); an operating voltage and simultaneously a control signal for the control circuit (73) may be applied via the input.

5. The sheathed-element glow plug as recited in Claims 2 through 4,

wherein the control circuit (73) includes a means for determining the temperature of the heating element; and the heating current is controlled as a function of the signal from these means.

6. The sheathed-element glow plug as recited in one of the preceding claims,
wherein the heating element is designed as a metallic or ceramic glow element (11).

7. The sheathed-element glow plug as recited in Claim 6, wherein the glow element (11) may be fastened in the opening of the combustion chamber by the use of a housing (10); and the housing (10) simultaneously represents a housing for the switch (70) and the control unit (73).

8. The sheathed-element glow plug as recited in Claim 7, wherein the switch (70) and the control circuit (73) are integrated on one chip.

9. The sheathed-element glow plug as recited in Claim 8, wherein the chip is applied in the housing (10) without packaging.

Abstract

A sheathed-element glow plug for self-igniting internal combustion engines is proposed, having an electrical heating element projecting into a combustion chamber of the internal combustion engine and having a current feed-through for feeding a heating current for the heating element through an opening in the combustion chamber. A switch is positioned in the region of the current feed-through, and the heating current may be controlled by the opening and closing of the switch.

(Figure 1)

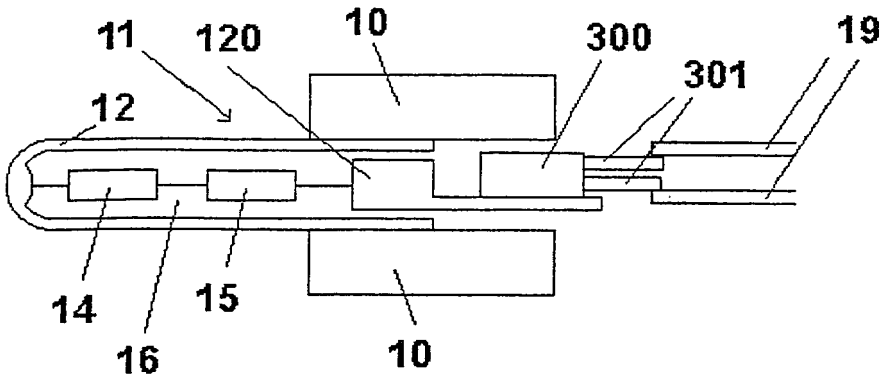
11
120
10
300
19
301
12
14
15
16
10

Fig. 1

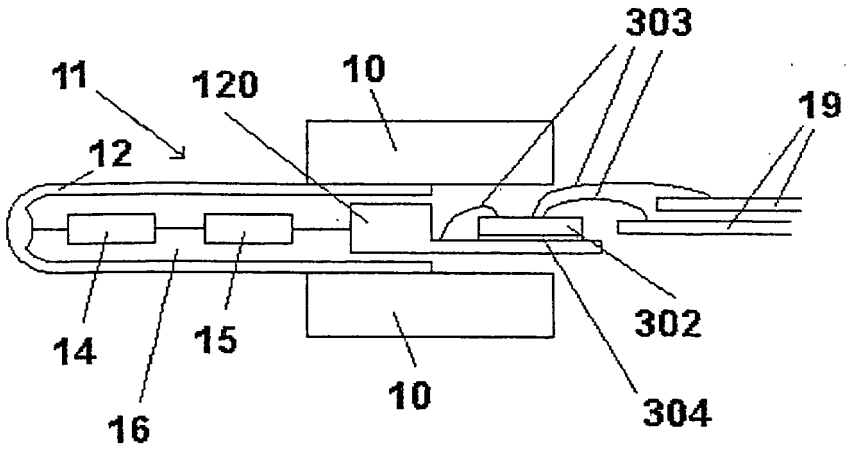
303
11
120
10
19
12
14
15
16
10
302
304

Fig. 2

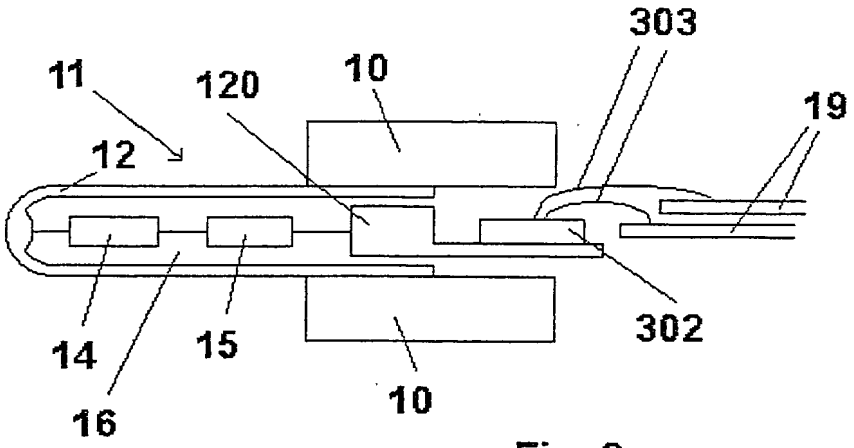
303
11
120
10
19
12
14
15
302
16
10

Fig. 3

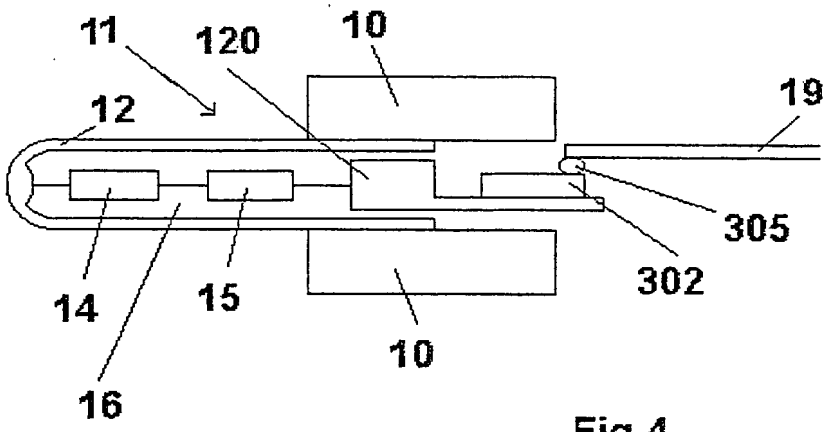
11
120
10
19
12
305
302
14
15
10
16

Fig.4

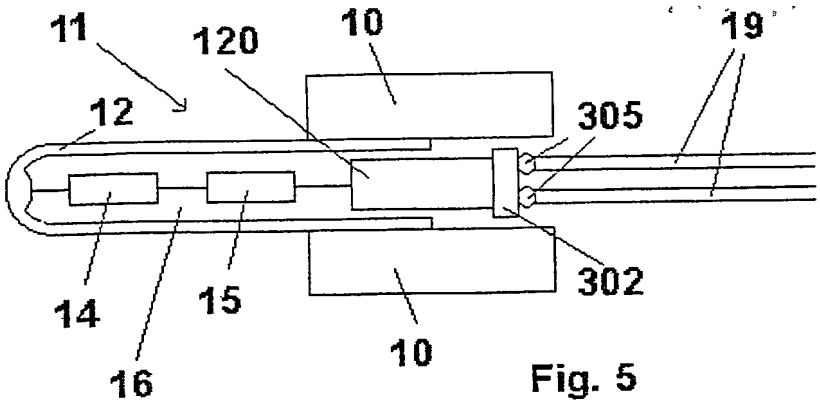

Fig. 5

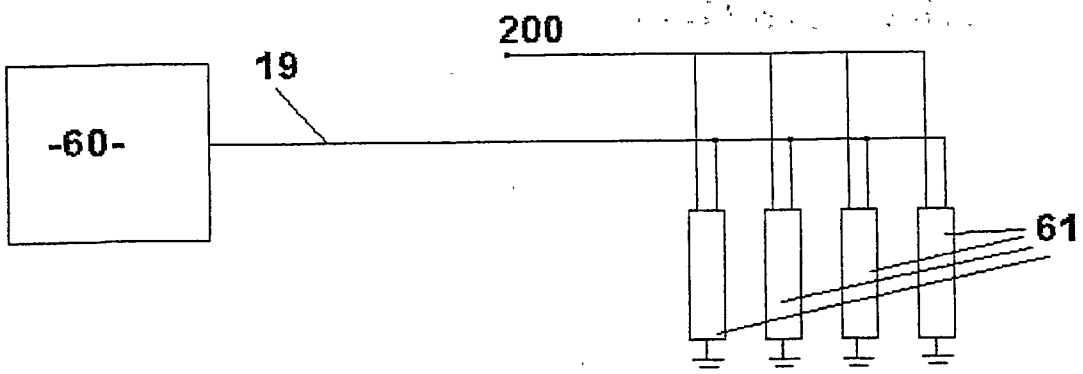

Fig.6

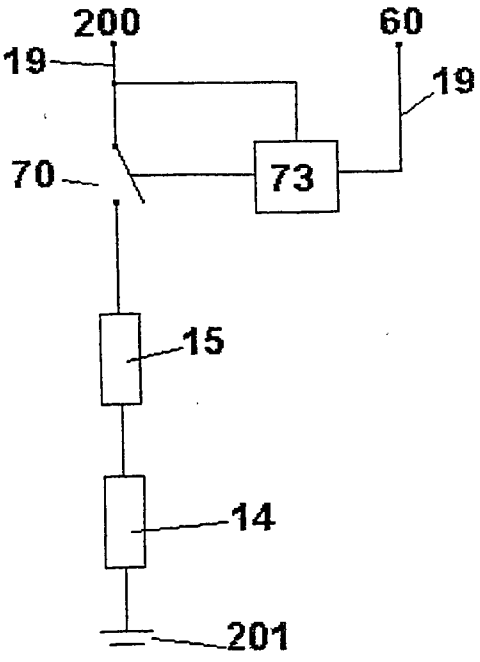

Fig. 7

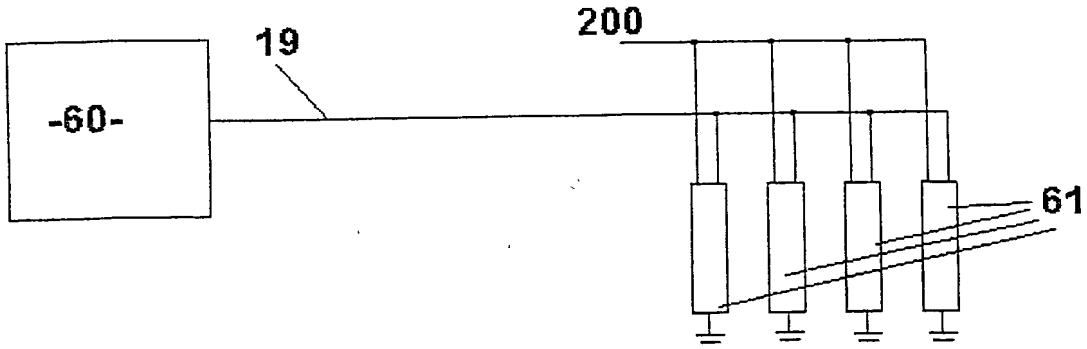

Fig. 8

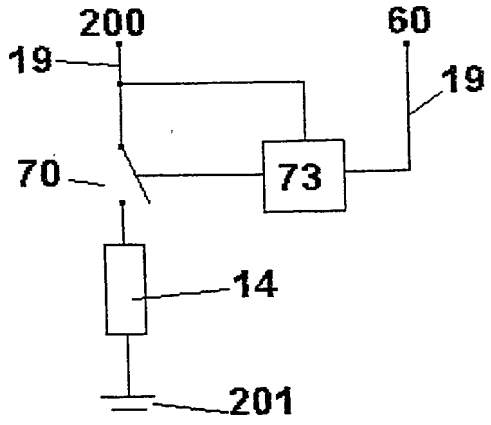

Fig. 9

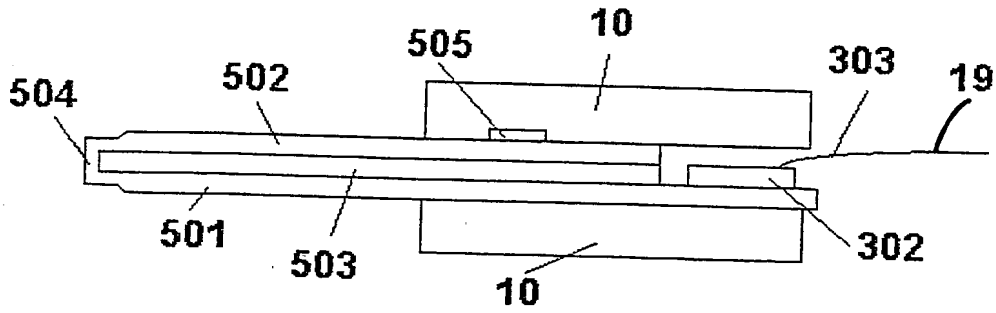

Fig. 10

[10191/2327]

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **SHEATHED-ELEMENT GLOW PLUG** and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No. and,

[x] was filed as PCT International Application Number PCT/DE00/02730, on the 12th day of August, 2000.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

EL 234417710
~~EL 594613122~~

PRIOR FOREIGN/PCT APPLICATION(S)
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

Number	Country Filed	Day/Month/Year	Priority Claimed Under 35 U.S.C. 119
199 44 193.6	Germany	09/15/1999	Yes

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR
PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

U.S. APPLICATIONS

Number :

Filing Date :

PCT APPLICATIONS
DESIGNATING THE U.S.

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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